Compressed Air

DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

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MONS. VICTOR POPP.

Compressed Air.

A MONTHLY PUBLICATION DEVOTED TO THE USEFUL APPLICATION OF COMPRESSED AIR.

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As the cold weather approaches we wish to call attention to certain precautions which may be applied to compressed air installations, and which will prevent the annoyance and expense of freezing. Makers of air compressors of the compound type furnish intercoolers, which are placed between the air cylinders, and which serve to reduce the temperature of the air, as it passes between stages of compression. These intercoolers are nothing more than tubular condensers, commonly called surface condensers, the water circulating around the tubes, through which compressed air passes. In some of these the air passes on the outside of the tube and the water on the inside. However this may be, the principle involved is the same. These intercoolers require about 1 pound of water for each cubic foot of free air, the air passing at a pressure of 60 pounds per square inch. These coolers serve just as important a purpose as after coolers, as they do as intercoolers, and there is quite as much reason for after cooling compressed air as for cooling it between stages, because the after cooler, when properly installed, should bring down the temperature of the air tothe original point; that is, to the temperature of the atmosphere, and in this way moisture will be deposited before the compressed air is started through the line pipe to the work. If the air is started on its journey hot, and it traverses a line of pipe long enough and sufficiently exposed to reduce its temperature, we will have the conditions of a long drawn out condenser, moisture collecting on the inside of the pipe to form water and ice, at times completely closing the tube, through the incrustation on the inside. Now, in order to get this condensation, the temperature of the air must be reduced, and if we reduce the temperature at the receiver as low or lower than it is on the outside, there will be no chance for further reduction until the air is expanded. It is quite possible at certain seasons of the year to obtain such thorough after-cooling as to prevent freezing even in the engines during expansion, for we may safely say that if the temperature of the air never goes below that to which it is brought in the after-cooler, there will be no trouble from freezing, and it is quite impossible to get too low a temperature in the after-cooler, because no matter how we may shrink the air by cooling, we are all the time drying it, and when we start it through the service pipes and it meets there higher temperatures, we will then be reheating under natural conditions, the air taking up heat from the atmosphere without expense and after having been dried.

Col. Beaumont, R. E., of England, who died in London recently, was an engineer of experience and much ability, especially in pneumatics. In 1880 a system of pneumatic traction, designed by Col. Beaumont, was put into experimental use at the Woolwich Arsenal, London. The in-

teresting point about this experiment is the fact that compressed air was used at high pressure and the engine was so constructed, that it might utilize the entire power stored in the air, no matter how high the initial power might be. One thousand pounds per square inch was the pressure which Col. Beaumont thought best for this purpose. The air was admitted into successive cylinders, having different areas, commencing first with the smallest, and compounding as the pressure was reduced.

Provision was made for a larger consumption of air as the pressure fell in the reservoir. It is easy from our point of view to-day to anticipate difficulties, which might arise in such a system as this. In the first place, the condensation of the moisture in the air would naturally cause an accumulation of water in the cylinders, and would result in freezing and interference with the machinery. This was at a time, too, when the Mannesmann steel tube had not been constructed and it was difficult to maintain air at high pressure in safe storage vessels. Like most pneumatic tram car experiments, this one was not continued to a successful issue for the lack of funds, but it is of special interest, in that it was a high pressure system, as distinguished from the low pressure systems which followed it, and which were approved by engineers up to recent years. Col. Beaumont was a firm believer in the high pressure system and held his views on this subject to the last. He believed in storing the air at high pressure on the cars, and in accomplishing pneumatic traction by the storage system, as distinguished from that which picks the air up at intervals along the line. Of the latter system, the Mekarski, Popp-Conti, Hughes & Lancaster, and Jarvis are conspicuous examples. The two systems now in operation, known as the Hoadley-Knight and the Hardie, are those of high pressure, and follow the Beaumont idea, which is now made practicable by the use of the reheater, and the Mannesmann tube. By means of the reheater the temperature of the air is raised so high, that freezing, even in compound cylinders, does not take place, and the Mannesmann tube furnishes a means by which air at high pressures may be safely stored in small areas.

We desire to call special attention to the original papers, published in the September and October numbers of this journal, written by M. Victor Popp. M. Popp has given our readers from a historical, theoretical, and practical standpoint, a description in detail of the system of compressed air distribution in the city of Paris. It must not be forgotten, that the largest compressed air installation, exclusive of mining plants, is that in the city of Paris, known as the Popp system, and that it has been in operation, passing through several experimental stages, since 1879, when a small plant was installed on St. Anne street, for the purpose of operating pneumatic clocks. From this beginning, there has been developed in Paris a plant of 8,000 horsepower, which has been admirably described by M. Popp, and the success of which is proved by its long and permanent use. The importance of reheating compressed air, which M. Popp has shown so clearly under the heading "Qualities of Compressed Air," is worthy of careful study by pneumatic engineers. M. Popp figures the theoretical efficiency of a compressed air plant, using the air cold, at 37 per cent., and it is interesting to note that tests made by a commission appointed by the Ministry of War have demonstrated the correctness of this theory, this test showing, that in a case where there were no leakages, the result was an efficiency of 42 per cent. M. Popp goes on to say that "there is no limit to

the number of calories, which can be added to the air, except that a too high elevation of temperature should be avoided, as it might prove either inconvenient or dangerous."

M. Popp goes on to show that "to obtain a nominal horse-power at the end of the pipe line, we have to use 1.5 kilogrammes of coal, of which 900 grammes are used at the Central Station and 250 grammes at the terminal point for reheating. This gives us an efficiency of 78 per cent. and is under all conditions superior to the best results obtained by electrical power transmission."

The comparison with the hot air engine is interesting in that by means of compressed air, we may through reheating approach the very economical results given by hot air engines. These engines have a limited use because of the complications in their construction, the microscopical adjustments required, and not because of a lack of efficiency. Hot compressed air used in common engines, is not subject to these criticisms, but by means of compressed air we may transform heat into power directly through the piston of an engine. The reheaters usually employed in Paris are oil or gas stoves surrounding the pipe, the heat being applied through radiation. Other systems of heating are in use, and we expect to see important developments in this line.

Facing the Thames embankment in London is a statue of Brunel, the great English engineer. Brunel was prominent in many things, but it must not be forgotten that he was the first man to practically apply compressed air for commercial service. Compressed air, though as old as the hills, dating back tothe time of Hero of Alexandria, was of little use to the world except for experimental purposes until Brunel used it in sinking caissons while building bridges over the Thames. Its importance for caisson service cannot be overestimated, as without it, it is doubtful that we should have built such piers as those at the Brooklyn Bridge, the St. Louis Bridge, and many others, where deep foundations are necessary. The use of compressed air in caisson service led to its use in diving bells, which were at one time of great importance in excavating under water. Of late years the diving bell has been replaced by the diving suit, and this is also an important use of compressed air.

Miscellaneous Applications of Compressed Air

Compressed Air and its distribution for power purposes in the city of Paris; how it is produced, its numerous applications and its cost—Continued.

By M. Victor Popp.

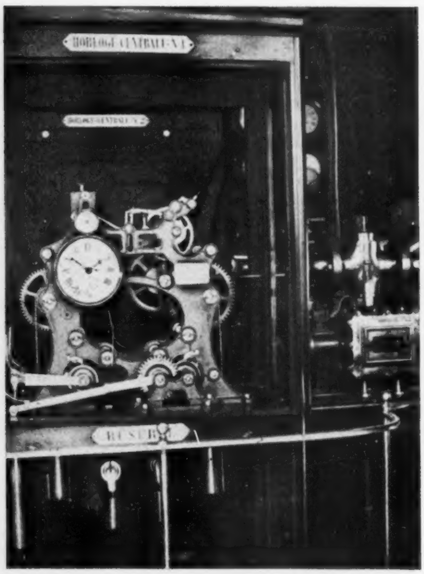
The following tests on the distribution of Compressed Air through main pipe lines have been made in Paris.

Loss of Air.

The loss or decrease in pressure of compressed air in main pipe lines is due to either or both of the following causes: The loss in weight of air caused on account of leakage and the loss in pressure due to friction. Both of the above are of great importance and should be taken into consideration. The leakages, if properly attended to in due time, and if the main pipe line is kept fairly tight, do not require much attention as it is the duty and to the interest of any central compressed air power plant engineer to reduce then to a minimum. They remain a constant factor of loss in amount of air furnished.

The loss of compressed air through leakage is about proportional to the number of fittings, such as T's, elbows and valves in-

stalled on the main pipe line, and that it amounts to about 6 per cent. of the total capacity of the plant. As this is a constant percentage of loss for an even pressure, it will be readily seen that if the plant were of 24,000 H. P. capacity, the total loss of compressed air would be only 2 per cent., it being 6 per cent. for 8,000 H. P.



HOUR SERVICE—CENTRAL CLOCK IN ITS CABINET.

Loss or Reduction of Pressure due to Friction in the main pipe line.

The reduction in pressure due to friction is a question of the greatest importance, and in order to determine same and to avoid its being excessive, it is well for the owners of the central power plant to thoroughly investigate the following results.

A great many experts had formed an opinion that loss due to friction would not amount to much, and Mr. Arson's experiments had led the company to believe that the loss would be very small, but all these experiments and tests were made with compressed air at low pressure and consequently low density. The company, however, decided to satisfy itself thoroughly, and engaged Prof. Gutermuth to make thorough tests, which were always made at night and on Sundays, when the traffic and supply were practically steady. These tests have proved that extraordinary loss of pressure was due to short bends, principally in the smaller branch pipe lines running uphill, notwithstanding the large diameter of 12 inches and the great number of receivers and automatic water traps connected with same. Thus it was decided to make thorough tests to determine the loss of pressure due to the receivers placed in pipes, and then in the main and branch pipes between the receivers. The table published below gives the results obtained.

Loss of Air Pressure due to Friction for one Receiver.

Pressure at entrace of receiver.	Pressure at outlet of receiver.	Loss.	Average speed of air per second through pipes.
92.84 lbs.	91.87 lbs.	0.97 lbs.	19.8 feet.
92.36 "	91.28 "	1.08 "	19.1 "
71.74 "	69.23 "	2.51 "	28.7 "
95.25 "	93.05 "	2.20 "	24.4 "
90.11 "	89.08 "	1.03 "	18.5 "

The figures show positively that for each receiver there is a loss of 15 per cent. of one atmosphere when the speed of air amounts to seven metres (23 feet per second), and that for 9 metres (30 feet per second), the loss due to friction amounts to 0.2 of one atmosphere. Thus it will be seen that five receivers placed one behind the other will cause a decrease of pressure of one atmosphere.

Twenty-three automatic water traps which were installed at different places on the main pipe line, did not result in any perceptible loss of pressure. The following table giving the number of tests and

mentioning the places where they were made, will give the reader a fair idea of results to which reference has been made.

Experiments in different Conduits used for the transmission of Air to determine their resistance.

Section of Conduit	Length, Miles	No. of Tests
Total length from the Central Station at Saint Fargeau across the City and return	10.28	7
From the Central Station to rue Fountaine-au Roi	8.15	3
FromCentralStation to rue de Charonne.	7.50	4
From Place de la Concorde to Saint Fargeau	5.75	5
From Station at Saint Fargeau to rue Fountaine au Roi	2.08	
From Station at Saint Fargeau to Place de la Republique	1.066	3 2
Isolated tests conduits of different lengths	0.445 4.57	11
From rue de Charonne to rue Fountain au Roi	5.44	..
From rue de Charonne to Saint Fargeau.	2.74	8

The above table relates only to tests made at night while the distribution of air was practically at a standstill, and the whole compressed air plant at the disposal of the engineers in charge of the tests. Some tests, however, have been made while the plant was in full operation and while the compressed air reached the endless main pipe line experimented upon through both ends. The experiments were made at a place situated respectively four and five miles from the central power plant, and all readings were automatically registered by automatic recording pressuse guages placed at convenient places. All tests were thus made on a main pipe line having a total length of nine and one-half miles and fitted with four air receivers, twenty-three automatic water traps and forty-two gate valves. The resistance or loss of pressure was made under different speeds of compressed air varying from zero to 50 feet per second.

I desire to emphasize that in the main pipe line of Saint Fargeau—Fontaine au Roi—which does not contain any receivers, it has been demonstrated practically that with a speed of 6½ metres (20½ feet per second), the loss due to friction amounts to 0.05 atmosphere per kilometre (3,300 feet) of main pipe line.

Thus admitting that the original speed of the air be 6½ metres (i. e., 20½ feet per second), and the original pressure 14.7 pounds above the atmosphere, a main pipe line of 20 kilometres length (i. e., 66,000 feet) would not be adequate to transmit any power.

A series of tests made on the main pipe line in Paris over a length of 16½ kilometres (i. e., 55,000 feet), with an average air speed of six metres (i. e., 20 feet per second), has demonstrated that the loss due to friction amounts to 0.07 of one atmosphere per kilometre. Thus it is clearly proved that the forty-two gate valves, the twenty-three water traps and the four receivers do not represent a great percentage of loss and taking as a basis that any air pipe line will be fitted with about the same number of syphons, receivers, valves and traps as the above-mentioned line, it will be seen that a total length of main pipe of 14 kilometres (i. e., 46,500 feet) will produce the loss of one atmosphere. This result is the best ob-

Compressed Air Municipal Clock.

tained up to this time for such a length of main pipe line.

In addition to the above, it has not been mentioned that the main pipe lines in Paris contain a certain number of elbows and grades, which certainly increase the loss of friction to a certain extent. The tests having been made under different air pressures, it has been found that the practical loss of pressure due to friction does not proportionally increase with the pressure or with the density of the compressed air at least up to 60 pounds above the atmosphere, but it is demonstrated that in order to reduce the loss of pressure due to friction to a minimum, it is best to carry a high air pressure.

APPARATUS FOR THE DISTRIBUTION OF TIME SERVICE. POPP SYSTEM.

Several installations which have given very good results are transmitting compressed air at various pressures of from 30 to 50 atmospheres, and in one case 160 atmospheres. The mechanical work necessary for compressing to high pressures is in proportion to the increase of pressure; for instance, the mechanical work required to compress air from ten to twenty atmospheres, represents only 30 per cent. of the total mechanical work required to obtain the result.

It is thus possible to produce high pressure compressed air at a small cost, to convey same for long distances through small main pipe lines with less loss of pressure than if the pressure was low, and this can be done with less loss of power than any other motive power, such as water or electric power transmission. The transformation from high into low pressure for the operation of motors is effected without any difficulty at the place where the power is used, this being done by an automatic pressure reducing valve. We will not, however, discuss here the very high pressure system, but confine ourselves to the medium pressure system, which is in practical use in Paris. The loss of pressure due to friction being one atmosphere for 14 kilometres (i. e., 46,500 feet), it will be easy to determine the loss due to friction in very long main pipe lines. As the resistance or loss of pressure due to friction decreases when the size of the main pipe line is increased, theory and practice have demonstrated that for doubling the diameter of the main pipe line and conveying the same amount of air at the same pressure through the larger pipe, the loss of one atmosphere would correspond to a length of about 40 kilometres (i. e., 132,000 feet); or, in other words, should the main pipe line be 100 kilometres long (330,000 feet), the pressure at the central station seven and one-half atmospheres, and the loss due to pressure one-half atmosphere, there would be a total loss of 7 per cent.

between the central power station and the end of the pipe line.

Other experiments have decidedly demonstrated that a main air pipe line of 600 milimetres diameter (i. e., 24 inches), will be commercially fitted to transmit 24,000 H. P. without excessive loss, and it has been furthermore established that if transmission of power exceed 40 kilometres (i. e., 25 miles), compressed air will be a better medium than water or electricity.

Compressed Air Motors.

In order to utilize the full power accumulated in compressed air and to obtain all the energy possible, it is found necessary to reheat the compressed air and utilize same. The object of reheating is to expand the compressed air, or, in other words, to increase its volume while its pressure is kept constant. Prof. Reidler, who is considered as one of the best authorities on compressed air, mentioned in his lectures that M. Victor Popp was the first to successfully use the reheating system with good results. Reheating of compressed air, however, had been done for a long time in mining work, but had never given good results, and was used principally in order to avoid the freezing of exhaust pipes of the motors or other machinery operated by compressed air.

The reheaters used in the Popp Paris installation are of the cylindrical jacketted type, the air circulating through the jackets, while the heat derived from the fire inside of the cylinder is absorbed by the air after being deviated by means of a series of baffle plates. The results obtained have given very good satisfaction.

It has been seen above in relation to hot air motors that the amount of heat stored in the compressed air is almost entirely transformed into mechanical work. Even with cast iron hot air motors, it has been proved that 80 per cent. of the heat was practically used. The table below shows the efficiency of several kinds of reheaters.

Table of Air Reheaters.

Nature of Reheater	Surface of the Heater in sq. meters	Volume of Air heated per hour in cu. meters	Temperature of the Air in the Heater C°		Number of Calories transmitted per hour		
			When Entering	When Leaving	Total Calories	Per sq. meter of Surface Calories	Per kilo. of Coke Calories
Cast Iron Tubular Heater...	1.3	576	7°	107°	17900	13760	4470
Wrought Iron Heater.......	1.3	313	7°	184°	17200	13230	4530
Stove	4.3	1088	50°	175°	39200	9200	5600

AIR REHEATER.

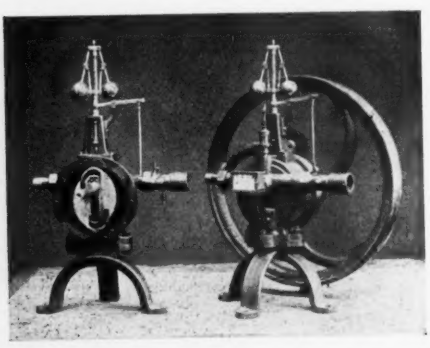
The experiments from which this table was compiled were made by Prof. Guter-

muth and show that one kilogramme of combustible will, under good circumstances, give up as much as 5,600 calories in an air reheater. This result being superior by at least 500 per cent. to the result obtained by the best triple expansion compound condensing engine, the ques-

AIR REHEATER.

tion of reheating the air using same, is entitled to serious consideration.

The amount of coal required for reheating air (for large motors) being about 0.09 of one kilogramme (i. e,, 0.2 of the pound per H. P. per hour) 0.2 of one pound is so small that it hardly needs to be taken into consideration, and thus in transmitting heat directly to the compressed air, the decrease of net efficienchy of the fuel burned for reheating same is more than six times as efficient as



COMPRESSED AIR ROTARY MOTOR.

that used to produce the compressed air. Thus 0.1 of one kilogramme (i. e., 0.22 of one pound), will produce the same mechanical work in reheating as 0.6 of one kilogramme or 1.3 pounds of coal through the medium of boilers and economical engines.

If the reader wanted to thoroughly investigate the above assertions and results of experiments, it will be seen that for a very small increase of combustible it will be possible to transmit large quantities of compressed air a great distance and make up not only the loss incurred through friction, etc., but obtain at the end of the pipe line a larger power than that originally pumped into same. For ordinary length of pipe lines and with reheating to 250 degrees C. above the atmospheric temperature, the power obtained at the end of the line was 30 per cent. above the power originally required to compress the air.

(Continued.)

Compressed Air Machinery

Report on Trials made at Magog, Quebec, to test the economy effected by preheating Compressed Air.

By Prof. J. T. Nicolson, D. Sc. (Edinburgh & McGill) M. Inst. C. E.

These trials were made during the month of April, 1899, at the Dominion Cotton Mill, Magog, Canada, where there is installed a 150 horse-power hydraulic air compressing plant on the system devised by C. H. Taylor of Montreal.

They were made at the instance of Mr. John A. Inslee, of St. Louis, and conducted under the auspices of Mr. Inslee, the Taylor Hydraulic Air Compressing Co., and the Dominion Cotton Mill Co., jointly.

The trials were conducted by the undersigned, assisted by Professor R. J. Burley, B. Sc., etc., of McGill University, but a number of prominent engineers

from the United States were invited to be present and took part in the experiments. Among others I may mention Mr. A. Langstaff Johnson, of Richmond, Va., Mr. Wm. O. Webber, of Boston, Mass., and Mr. John Birkinbine, of Philadelphia, Pa.

Experiments were made on five different methods of using compressed air in an ordinary steam engine of the Corliss type.

1st. The air was supplied to the engine cold.

2d. Steam was injected into the air in the main pipe before supplying it to the engine.

3d. The air was injected among the water in a steam boiler and heated by mixing with the water and steam of the boiler before being supplied to the engine.

4th. The air was blown upon the surface of the water in a steam boiler and heated, by mixing with steam in the same before being made to drive the engine.

5th. The air was passed through a tubular heating vessel and heated by a coke fire, afterward being used to work the engine.

For all the experiments the air was drawn at a pressure of 53 lbs. from the 5-in. main air pipe of the Taylor Air Compressor, which supplies power to the mill, and was piped to a 12-in. diameter by 30-in. stroke Corliss engine, supplied for the purpose of the trials by the Laurie Engine Company, of Montreal.

A friction brake was fitted on the fly-wheel of this engine and the engine in this way was worked up to its full power at about 75 revolutions per minute.

Connection was made to a Lancashire boiler 7 ft. diameter by 30 ft. long when it was desired to mix steam with the air for purposes of pre-heating.

When dry heating was resorted to the air pipe was led through a heater on its way to the engine, having been previously blanked off from the steam boiler. This heater was designed by the writer and built by Messrs. The Laurie Engine Co., for these experiments; but, as it was designed of such size as to heat the whole of the compressed air used in the mill, it was considerably larger than was required to heat the greatest quantity of air which could be used by the Corliss engine employed on the test. It was, therefore, a matter of some difficulty to prevent the heater and the small quantity of air passed through the same from becoming hotter than was desired.

For the experiments made without pre-heating the observatons made were as follows:

The temperature of the air before entering the engine.

The same on leaving the engine.

The pressure of the entering air, indicator cards from each end of the cylinder, readings of the revolution counter and of the rope brake weights.

A trial was conducted with cold air on April 27th, in the presence of Mr. Birkinbine, which gave the following results:

The air entered at 66.5 F. and was exhausted at —41 F., the revolutions being 74.6 and the cut off about one-third of the stroke. The indicated horse-power was 27 and the weight of air used per hour was 1.671 lbs. This gives about 841 cubic feet of free air at 60 F. per I. H. P. hour.

On another trial made under same conditions 850 cu. ft. of free air were used per I. H. P. hour.

2. In the case of experiments made with the dry heating, the following observations were made:

The temperature of the air before entering the heater; after passing up the first row of tubes; upon leaving the heater; before entering the engine.

The temperature of the furnace and flue gases of the heater were also taken, the former with a Callendar's patent electrical promoter.

The amount of coke (Sherbrooke gas coke) used was carefully weighed and the trial only began when the conditions had become steady, i. e., about three hours from the time of beginning the run with heated air. Cards were taken; the brake horse-power and the revolutions were also observed.

With air entering the heater at a pressure of 53½ lbs. gauge and at a temperature of 58.2 F., it was raised to 225 F. after passing the first row of tubes, and to 363 F. upon leaving the heater. Owing to undue length of air pipe and lack of proper covering, the air fell in tem-

perature to 287 F. before entering the engine. It was exhausted at 88 F. and the pressure at the engine was 52½ lbs. by gauge.

The temperature of the gases leaving the fire was only about 700 F.—and was reduced to 100 F. in the flue of the heater. It was difficult to use a small enough quantity of coke in such a large heater without letting the fire out altogether. A closed ash pit was used and the air for combustion supplied from the compressed air main and could be regulated in its amount to a nicety.

Under these conditions and with exactly the same cut off as in trial of cold air, the indicated horse-power being 26.7 and the revolutions 70 per minute, there were used 1,310 lbs. of air per hour, this gives a consumption of 640 cu. ft. of air per I. H. P. per hour, a reduction of 850—640—210cu. ft. of free air per I. H. P. per hour due to pre-heating. Thus 210-850, a saving of 24.7 per cent. is effected in the quantity of air used.

This saving was effected by the burning of 9.3 lbs. of coke per hour, or of 9.3-26.7 348 lbs. per H. P. per hour.

These results may be stated otherwise as follows:

To produce 100 H. P. with cold air, 85,000 cu. ft. of air were required in this engine; when pre-heated to 287 F., the horse-power yielded was 85,000—640—133 H. P., and as this heating was effected by the burning of $\frac{9.3 \times 133}{27}$ 47 lbs. of coke per hour; the additional 33 H. P. were obtained by an expenditure of 47 lbs. of coke per hour, or at the rate of $\frac{47}{33}$ 1.42 lbs. of coke per hour additional.

If we assume that this gas coke had ¾ of the calorific value of good coal, it is seen that we obtained an additional horse-power for every (1.42x¾) 1 lb. of coal burnt in the heater.

As an ordinary steam engine and boiler of this size would require from 4 to 8 lbs. of good coal per H. P. per hour, it is seen what a very economical mode of using the heat this is. Heat is used 4 to 8 times as efficiently in a compressed air pre-heater as it is in a steam engine and boiler.

With regard to the results of this trial it ought to be remarked that a large radiation loss per lb. of air used was taking place, both on account of the undue size of the heater and on account of its distance from the engine. Much more favorable results can be and in fact, have been obtained, when the size of the engine and heater are properly proportioned.

Professors Riedler and Guttermuth have obtained an additional horse-power in air motors for every ¾-lb. of coal burnt to heat the air. This is an economy far surpassing that of any prime motor in existence.

In large plants with first-class air motors, where double or triple pre-heating might be resorted to, a better result than even this can easily be obtained.

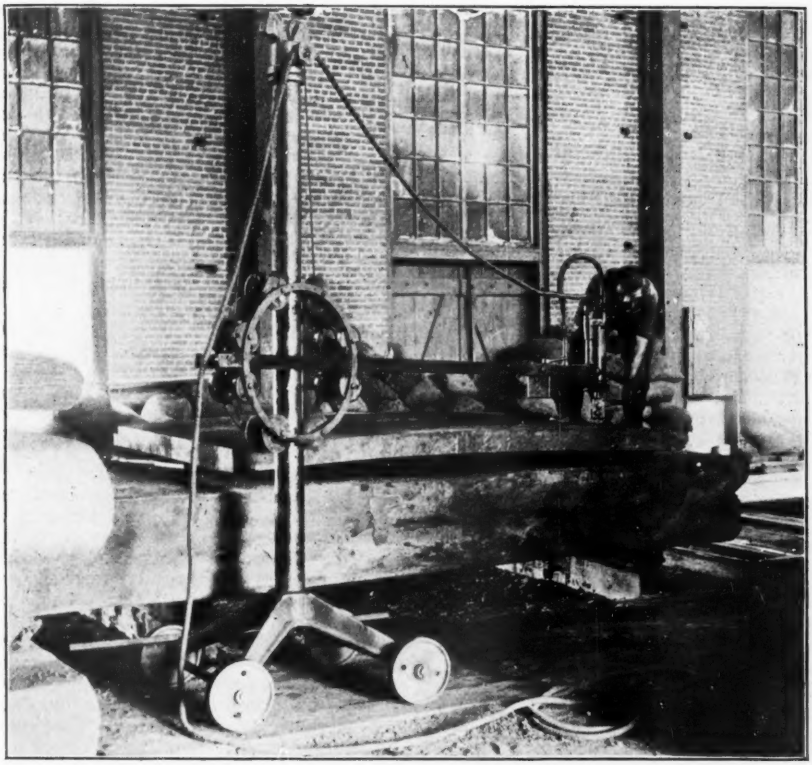
In a large transmission plant consisting of a Taylor Air Compressor, a five-mile pipe line, air engines and electric generators, with coke pre-heating stoves, the full or gross power of the water fall can be obtained at the terminals of the dynamo, at a comparatively insignificant cost for fuel.

No other system of energy transmission can compare with this for economy of first cost and maintenance.

3. Tests were made of the economy to be obtained by heating the air by mixing it with steam from a boiler before allowing it to do work in the engine.

The results are of the highest scientific interest, and show the adaptability of compressed air to almost any condition of employment. As regards economy, this method is, however, inferior to that of dry heating. By mixing from 10 to 13 lbs. of steam per H. P. with the air, the quantity of air required was reduced from 850 cu. ft. to 300 to 500 cu.. ft. per I. H. P. per hour. Thus the air required for a 100 H. P. engine running with cold air would be sufficient to operate an engine of 85,000—400—210 H. P. if mixed with 12½x100—1,250 lbs. of steam per hour. This can be supplied by about 140 lbs. of coal per hour; so that 110 H. P. additional were obtained by the burning of 140 lbs. of coal or 140—110—1.3 lbs. of coal per I. H. P. per hour additional.

Such a method of heating, economical as it may appear, would however, be unsuitable except for powers of over 50 H. P. unless waste steam is available from a boiler plant at times of low demand.



THE MACCOY MACHINE FOR REMOVING SCALE FROM ARMOR PLATE.

Traction and Auto-Mobile

Liquid Air for Automobiles.

We none of us know now as much as we will know a little later about the best methods of using liquid air, whether for power, for refrigeration or for other service, or of the practical value of the effects realized in proportion to the cost. As it has been suggested that liquid air may be made serviceable for the self-propulsion of road vehicles, it seems to be in order to offer some suggestions or to indulge in a little speculation, as to the way to do it and as to what would come out of it.

Liquid air represents, among other things, stored energy, and energy which may, partially at least, be reconverted and employed for our service. Liquid air is compressed air in an easily portable form. The advantage which it has over high-pressure, non-liquefied, compressed air is that it is not dangerous to convey or to hold, and that it does not require many and costly bottles to contain it. The liquid may be carried in a milk can, or in anything that will hold water, and which is merely strong enough for the weight of the water without any added pressure, although it is quite imperative to surround the vessel with large quantities of heat-insulating material. Even with abundant insulation provided, a given charge

of compressed air in liquid form must weigh much less than the same charge under high pressure, and not liquefied but contained in the necessary steel bottles. The shape of the vessel in which the liquid may be conveyed may be made to conform to the conveniences ofthe vehicle, while high-pressure air insists upon its long cylindrical receivers, which must be disposed of as best they may.

In the previous article I spoke of using liquid air for maintaining supplies of compressed air in receivers of considerable capacity, and where the use of the air was slow or intermittent, the liquid air being occasionally inserted in charges sufficient to restore the fallen pressure in the receiver within certain predetermined limits. An entirely different system would have to be followed in the case of the automobile. All the liquid air for a trip, or for a run between charging stations, would be carried in the liquid state, and usually in a single receptacle, and there would be practically no compressed air reservoir, or any receptacle required for any considerable volume of compressed air after its re-evaporation. The liquid air would be pumped into the working compressed-air system just as it was wanted for use, and almost precisely as the feed water is pumped into a steam boiler. The boiler in this case would necessarily be of the tubular type, with the important difference from the steam boiler that the requirements for the evaporation of the air would not call for the assembling of the tubes in close proximity to each other and around or over the fire, for there would be no fire. The heat required would be obtained from the surrounding atmosphere, and the tubes, or the single continuous tube, would be so disposed as to get the best exposure to the air. In the automobile it would be most natural and proper to have the air traverse a coil spread out in front of the machine, so that the air would strike it with some velocity when the vehicle was in motion. After the air had by this means attained the temperature of the external atmosphere, its mechanical status and value would be precisely the same as that of compressed air which had been produced directly by compression in the usual way, except that the liquefied and re-evaporated air would be absolutely dry air, and would be entirely incapable of causing any trouble by freezing up in the passages of the motor. The air after attaining normal temperature might be passed through a reheater, heated by a little oil lamp or other means, and the consequent increase of volume would add considerably to the efficiency of the air as in other cases. If the air was used in a compound motor, it should certainly be passed through a reheater first, and also again before entering the low pressure cylinder. If the latter re-heating was not effected there would be little or no reason for compounding.

With this general scheme for using liquid air for an autocar motor, the vehicle that I have in mind just at present is a tricycle for a single person, and to be used for service similar to that of the present bicycle. Say that we have a receptacle that will hold 50 pounds of liquid air, or something over 6 gallons, and that 10 pounds of the liquid will be evaporated and lost during our trip through the park and up the boulevard, leaving 40 pounds of liquid air available for use. Our working pressure will be, say, 100 pounds to the inch. As a cubic foot of air at 100 pounds weighs, say, 6 pounds (see preceding article) we have available $40 \div 6 = 66$ cubic feet of air at 100 pounds. Our motor has a 1-inch diameter cylinder, 2 inches stroke, normal speed 300 revolutions per minute; connected to the driving wheels by differential gearing of wide range. Cutting off at quarter stroke, the mean effective pressure will be 44 (see Richards' "Compressed Air"), and the theoretical power developed will be: $1^2 \times .7854 \times 44 \times 100$ feet piston speed $\div 33.000 = .1047$ horse-power, and the air consumption per minute will be $1^2 \times .7854 \times 4'' \times 1/4 \times 300 \div 1.728 = .1363$ cubic feet, to which we should add 10 per cent., making the consumption .15 cubic feet per minute. As we have 66 cubic feet available, the charge should last $66 \div .15 = 440$ minutes, or say 7 hours, which, at 8 miles an hour, should be as far as any one should want to ride at one time, and it would only be necessary to pour in the liquid air again to be all ready for a ride as far again. With liquid air in sight as low as 2 cents per pound, this riding is distinctly cheaper than the maintenance of a horse. In the few figures here given nothing is said about the gain that might be accomplished by reheating. This it would be very proper to go into

for larger vehicles, and also the compounding of the motor. With air at an initial pressure of 200 pounds, and reheated both before entering the first cylinder and also intermediately, it should be easily possible to show results 50 per cent. better than here indicated.

Frank Richards.

Twenty-eighth and Twenty-ninth Streets Compressed Air Line.

The rankest exhibition of spite and criticism which has come to our knowledge in these latter days, and which approaches very closely to the border line of blackmail, is the article in the New York Journal of the 6th inst., concerning the air cars on the Twenty-eighth and Twenty-ninth Streets line of the Metropolitan Street Railway. As a misstatement of facts it is unique and impressive. The only charge that the writer makes that it is not a rank falsehood, or so near one, that it is no exaggeration to so state it, is the complaint of the dripping of oil from the car trucks along the track, a few inches inside of each rail. That is a fact, and it should not have been allowed to happen, but the company is using its whole endeavor to stop it. It is one of those unfortunate happenings which are possible with every undertaking, about the whole of whose details there is not the most exact knowledge. The air motors run in a dust-proof casing. The bottom half of this casing contains oil, and is sleeved upon the axle. In their anxiety to get the cars in operation, the glands for a stuffing box joint about the axle, where it leaves the casing, were not thought to be essential for the operation of the cars, and were not put on. But use has shown that they are a very important item. It is a misfortune that an experiment so successful in every way should have been marred by a happening which could have been so easily avoided.

The exhaust of the air motors makes so little noise that they are practically noiseless. They can be made absolutely so. That these cars make a little more noise than the freight dummies on West Street is probably true, for they make none; but the air cars make less noise, on the same grade of track, than the cable cars, and much less than the trolley cars; for their humming can be heard a long distance.

The track on Twenty-eighth and Twenty-ninth streets is not at all suitable for such heavy cars, nor for any car running at very high speed. These air cars are not, as charged, heavier than the electric cars, but are much lighter.

Another unfortunate condition, which militates against the smooth working of the air line, is the fact that there are no track crossings on the avenue lines, and the cars must jump the tracks, an act that is both productive of noise and jar; and is destructive of motors. We have ridden many times on these cars, both as a passenger, in a hurry to get along, and as a critic, willing to find fault. At first, we detected a vibration in the cars, the product of their reciprocating motors. This has been gotten rid of almost entirely. The seats over the air storage reservoirs are a little high and wider than the ordinary car seats. The fact that we were sitting over a possible volcano was entirely lost sight of, in our interest in the novel and certainly successful system.

Compressed air will be found in street railway traction to be more reliable than the cable or either of the styles of trolley, for certainty of action. If a constant patron of the different systems will observe the causes of all the detentions he either suffers, or is cognizant of, he will find that more of them will be chargeable to the cable or trolleys, than to the horse or air car. The cable has proven itself expensive, and its broken strands are a dread possibility. The trolley systems are subjected to a variety of accidents which occasion frequent detention.

If compressed air traction is given a fair chance to demonstrate its value in urban traction, it will be found to be the superior of electricity where absolute freedom from uncertainty is desirable. That as high speed can be maintained with it is doubtful, but speed is not the only desirable feature in any system.—Municipal and Railway Record.

Hardie Cars running in Chicago.

The compressed air motor cars on the North Clark street cable road in Chicago are making a good record for themselves, and much can be said of their reliability.

The first car made its initial trip May 30th; soon after the second car was put on, and a third car is held in reserve to provide for any emergency or accident.

No trouble has originated from lack of efficiency on the part of the inexperienced motormen. They were instructed originally by Robert Hardie, and have been able to handle the cars perfectly ever since.

The cars still continue to make the first trip from air that was left over from the previous night service, and, on one occasion, one of the cars made an excursion trip in daylight for the benefit of those who were invited to be present, and still made its regular trip at night with what air was left from the preceding night.

From May 30, 1899, to June 20, 1899, inclusive, car No. 107 ran alone. On June 21st car 102 was put in service, and since then two cars have been running regularly and doing the complete "Owl Car" service.

In order to show the actual service performed by these cars a brief table is given:

	Car No. 107.	Car No. 105.	Car No. 102.	T'ls.
No. of miles covered	1,232	189	616	2,037
No. of trips without trailer	148	21	84	253
No. of trips with one trailer	26	6	4	36
No. of trips with two trailers	2	—	—	2
Total No. of trips, each car	176	27	88	291
No. of passengers carried paid fares				24,294
No. of hours car service from June 21st to July 17th inclusive, for two cars				142
No. of hours compressor ran from June 21st to July 17th, inclusive				93h. 43m.

Pneumatic Tools

The Pressed Steel Car Co., of Pittsburg, made an interesting test of the New Boyer Long Stroke Pneumatic Hammer at their shops in Pittsburg during the week beginning Aug. 21st. Up to Aug. 28th it ran continuously day and night very rapidly and successfully driving ⅞" rivets with no breakage or stoppage. A feature of this hammer is that no expert riveter is required and in view of the large amount of work done and the continuous operation of the tool in the above test, the record is a very good one.

At the National Export Exposition, which opened in Philadelphia on Sept. 14th, the Chicago Pneumatic Tool Co. has installed an exhibit of compressed air tools.

At this exhibit will be shown the New Boyer Long Stroke Hammer for driving rivets from ¾ to 1¼" in diameter, the New Reversible Wood Boring Machines, the Henrikson Flue Cutter with reversible motor, the well-known Boyer Drills and Boyer Hammers for chipping and calking, the Haeseler Piston Drills, Phoenix Rotary Drills, and other pneumatic appliances, making a very full and complete exhibit of this line. In connection with this, they are placing an Electric Driven Air Compressor for operating the tools, so that we shall be able to make practical demonstration of the working of the tools for the benefit of foreigners attending the Exposition, and others interested in this line.

Their exhibit is in charge of a competent man, and the aim is to make it of great interest in every particular.

As an indication of the constantly growing favor with which pneumatic tools are received by railroads, ship yards and manufacturers generally, the leading manufacturers advertise that their sales of these tools for August, '99, have been equal in volume to our total sales for the year 1897. There is hardly a branch of metal working to-day but what has found it desirable to adopt the use of pneumatic appliances, and in plants where they started with a small outfit they have very largely increased the number of tools in use. Every month the trade in these tools has shown an increase over the preceding month, and the vastly increased volume of business, as stated, indicates that pneumatic tools have passed the experimental stage and are everywhere recognized as great labor savers. There is not a railroad shop of any importance in the United States where pneumatic tools cannot be found in successful operation, and the constant additions being made to such equipments show clearly that the officials in charge recognize their merits.

It is understood the world over that Americans are always the first to perfect and adopt labor saving appliances, and among such appliances, pneumatic tools have reached first rank. The demand for

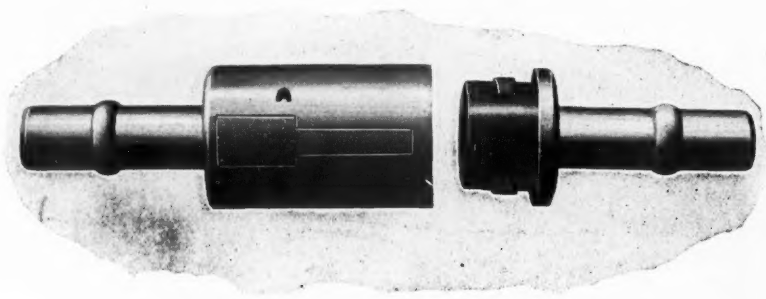
such appliances in all branches of metal working, has the company mentioned to bring out new tools from time to time, until now they have tools adapted to every requirement.

The accompanying illustrations show the Quick Acting Stop Coupling for Air Hose made from a design of Mr. E. B. Gallaher, engineer of the Pneumatic Supply & Equipment Co., N. Y.

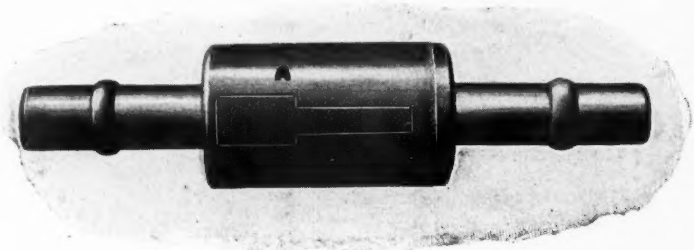
This coupling is designed especially for use in connection with pneumatic tools. It is both a union and a stop cock combined, and its use is desirable where compressed air tools or appliances are used. The operation is extremely simple—it may be locked or unlocked by a quarter turn and when locked it is absolutely air-tight under any working pressure. It is claimed that a saving of compressed air is effected and the necessity of shutting off the air supply at the receiver or main supply pipe is avoided. The use of this coupling permits one tool to be detached and another one to be connected to the air hose instantaneously and the annoyance of twisted hose is entirely obviated.

H. L. Frost of Bristol, Tenn., is manufacturing what is called the Pneumatic Water Elevator. It consists of an air pump elevator and an air receiver. The elevator is placed on the bottom of the source of water supply, the air is connected to the elevator and forces the water out of it and discharges it at any point above ground where it is wanted.

The Henrikson Flue Cutter for 4½" flues, is shown in the accompanying cut. This is a newly patented article and has been found very successful in operation that is now being manufactured and sold by the Chicago Pneumatic Tool Co. It is made in any size to suit requirements and has been adopted as standard on the Chicago and N. W. R. R. The cutting wheel is fed against the flue by the cylin-



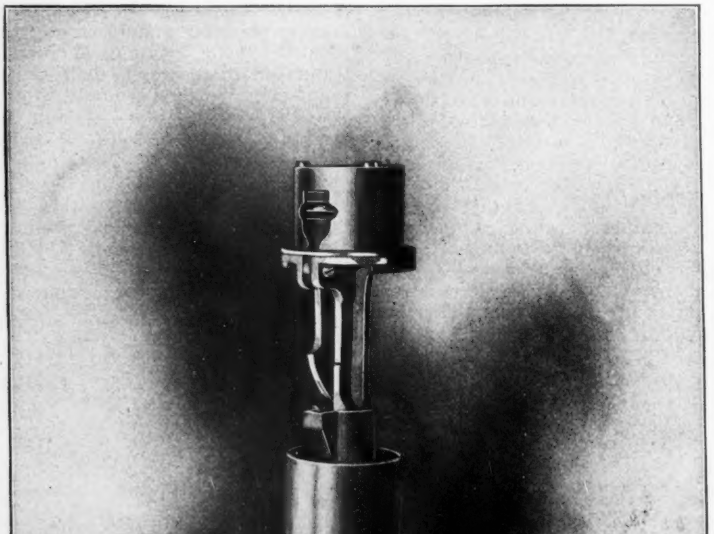
QUICK ACTING STOP COUPLING FOR AIR HOSE, UNCOUPLED.



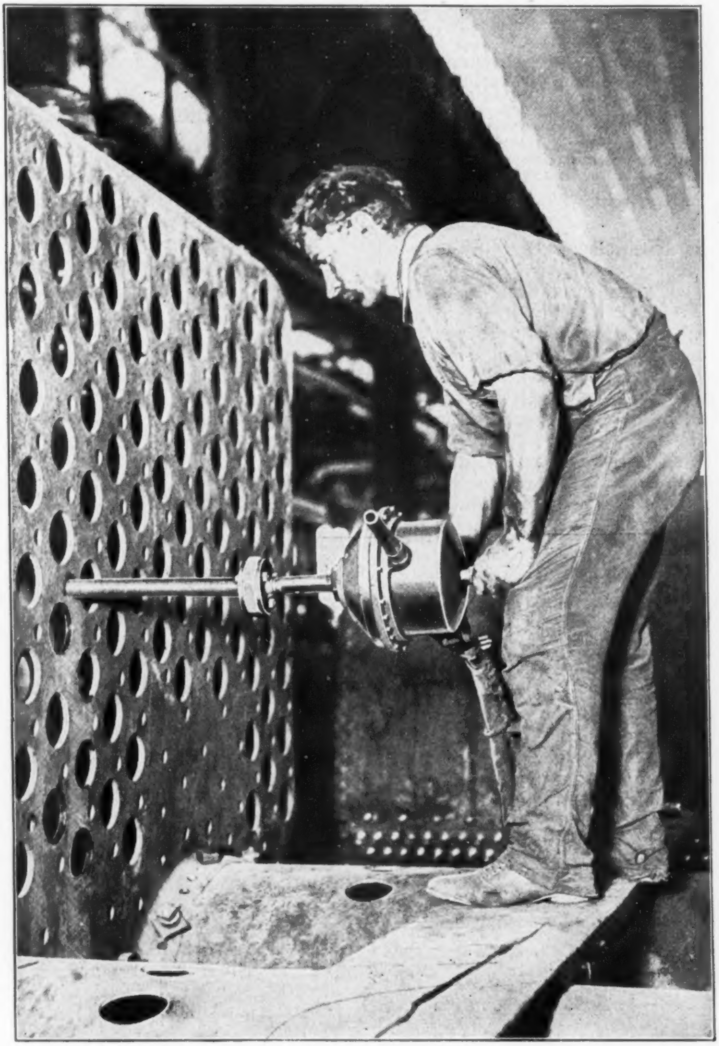
QUICK ACTING STOP COUPLING FOR AIR HOSE, COUPLED.

der and piston arrangement, shown about the middle of the machine, the air pressure passing through the motor to operate the piston, and the air motor revolving the cutter at the same time. The machine will cut off the flues either inside or outside the flue sheet and on 4½" flues it has been found very efficient, cutting them off in about 20 seconds, and in much less time on locomotive flues.

Any railroad mechanical man will very quickly appreciate the advantage of this tool, on account of the great saving effected in that the machine cuts off the flues close to the sheet, thus making but very little waste on the flues.



HENRIKSON'S FLUE CUTTER



GABRIEL STAY BOLT CHUCK.

The Gabriel Stay Bolt chuck is arranged to grasp any size stay bolt, and will turn them without the necessity of squaring up the ends. In operation with the air motor, as shown, it is very rapid and efficient and effects a great saving of labor in turning in stay bolts.

This is a small machine but great in its labor-saving qualities, and will certainly interest all users of such devices. It is an entirely new device, just patented, and will commend itself at a glance to all practical men.

COMMUNICATIONS.

Under this heading will be published inquiries addressed to the Editor of COMPRESSED AIR. We wish to encourage our readers in the practice of making inquiries and expressing opinions.

We request that the rules governing such correspondence will be observed, viz.. all communications should be written on one side of the paper only; they should be short and to the point.

San Francisco, Cal., July 21, 1899.

Editor Compressed Air.

I notice your quotation of an inquiry by J. T. B., and reply by the National Engineer, in your July number regarding the operation of a proposed air lift. I do not know who J. T. B. may be, but if he follows the advice given he will fail to get water. Here are the corrections that should be made to the reply:

The well will be better without the 5″ casing advised. The well casing, 6″, is better, by the difference in friction.

The flow will never be steady, but intermittent.

With the submergence given (125′) the supply of air will have to be between 14 and 15 times the water flown.

The reservoir pressure will be the submergence + friction of air pipe, i. e., 125 lbs. x .434 + say, 5 lbs. or less than 60 lbs. It will take 6 lbs. to start it.

If the well is operated singly, no receiver is necessary or advisable.

Finally, the air will operate with an efficiency less than 20 per cent. This efficiency is entirely independent of compressor efficiency.

G. S. D.

No. 1233 St. Charles St.,
Alameda. Sept. 24, 1899.

Editor "Compressed Air:"

Dear Sir:—Inclosed please find postal order for $2 in settlement of my subscription to your highly prized paper up to June, 1900.

As special agent of the Aetna Ins. Co. (fire) I spend most of my time away from home, and when I return the first thing my wife hands me is my pet, "the Compressed Air."

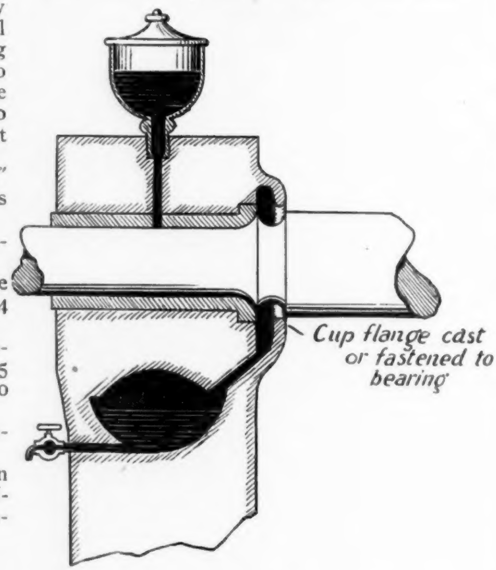
Wishing every success in your worthy enterprise, I remain, yours truly,

Louis Mel.

New York, Sept. 13, 1899.

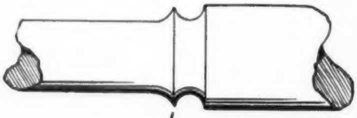
Editor Compressed Air:

One of the New York daily papers has commented quite severely on the Compressed Air Street Railway System now being operated on 28th and 29th streets, New York City. The main objection offered is the dropping of oil along the track. This is unquestionably a fair objection and one which must be removed before the system will give complete satisfaction. It is, however, a trouble which appeared in the earlier experiments with



electric motors and caused a great deal of annoyance and expense and some criticism. In the case of electric motors the trouble was remedied by adopting an enclosed motor and gear case and adopting a form of bearing which prevented the oil used in the gear cases from leaking out of the bearings. It is of course apparent that oil will, from capillary action, work through the bearings of the oil-filled case to the outside, and unless some means is arranged to catch this oil, it will be thrown off and collect under the car body and along the track. In the case of the air motor as used on the 28th and 29th street line the reduction gears run in oil to reduce friction and prevent noise. As far as I am able to determine,

no precautions have been taken to prevent this oil working through the bearings as described, and it would seem advisable for the railroad company to adopt



the simple method used by the manufacturers of electric motors, a sketch of which is sent herewith.

Yours truly,

Interested.

PATENTS GRANTED AUGUST, 1899.

Specially prepared for COMPRESSED AIR.

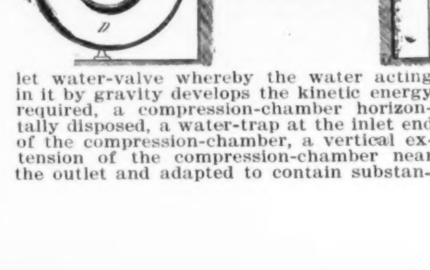
630,379. TRIPLE VALVE FOR AIR-BRAKES. William B. Mann, Baltimore, Md.

630,380. ENGINE FOR AIR-PUMPS. William B. Mann, Baltimore, Md.

630,381. APPARATUS FOR OPERATING AIR-BRAKES. William B. Mann, Baltimore, Md.

630,495. AIR-COMPRESSOR. Russell L. Dunn, San Francisco, Cal. Assignor of three-fourths to Clarence Stanley Preston and Frank Hanford, Seattle, Wash.

A hydraulic air-compressor, the combination of a motive-water pipe, connecting above with a source of water-supply, and connecting below with the casing of an in-



let water-valve whereby the water acting in it by gravity develops the kinetic energy required, a compression-chamber horizontally disposed, a water-trap at the inlet end of the compression-chamber, a vertical extension of the compression-chamber near the outlet and adapted to contain substantially the air volume after compression; an inlet water valve between the motive-water pipe and the water-trap, an outlet waste-water-discharge valve from the compression-chamber, adapted, also, to admit air to the chamber, a compressed-air outlet valve, valve-operating mechanism for operating the inlet and outlet water-valves successively and continuously, and means controlling the entrance of water to said pipe whereby the amount of kinetic energy developed may be adjusted by regulating the amount of water acting in the motive-water pipe.

630,525. AIR PUMP OR COMPRESSOR. Charles O. Sobinski, St. Louis, Mo.

In an air pump or compressor, a cylinder, a piston and piston-rod thereof, a drive-shaft, a suitable dog in connection with the piston having a longitudinal slot, a lug projection from one end of the longitudinal surfaces of the dog, a pin carried by the lug, a guide-pin projecting longitudinally the length of the dog and projecting from one end of the same for guiding the dog, cam-slots for the travel of the pin carried by the lug, and intermediate connections between the dog and the drive-shaft for actuating the former and reciprocating the piston upon rotation of the drive-shaft, substantially as set forth.

630,821. PNEUMATIC PROPULSION MEANS. Jas. C. Walker, Waco, Tex.

An improved propellor-shaft in ship-propulsion means of the character described, comprising a hollow shaft tapering toward its outer end, said end terminating in a discharge-nozzle blowing directly rearward and having at said end radial air-outlets, its inner or feed end having a back-pressure valve; a boss mounted on its outer end having radial discharges e^{10}; radial hollow arms communicating with the discharges e^{10}, and hollow blades secured to said arms, having discharge orifices; said blades and arms being made of diamond shape in cross section, all being arranged substantially as shown and for the purposes described.

630,938. CONTROLLING MECHANISM FOR ELECTRIC RAILWAYS. Sidney H. Short, Cleveland, Ohio. Assignor to the Walker Company of New Jersey.

In a pneumatic controlling mechanism for electric-railway cars, a controller and a reversing-switch, pneumatically-operated means for actuating said controller and switch, said means operating to move said switch in advance of the movement of said controller, and means for locking said switch, as and for the purpose set forth.

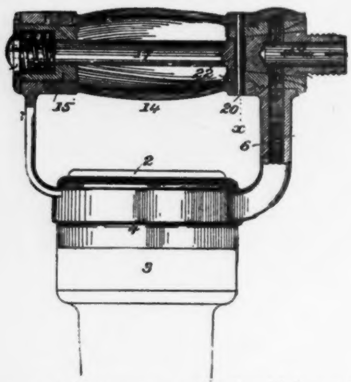
631,377. AIR CLEANSING AND COOLING DEVICE. Joseph McGreery, Toledo, Ohio. (No model.)

An air cleansing and cooling device, consisting of a case provided at its top with an air-inlet and a water-inlet, and at its bottom with an air-outlet and a water-outlet, and between the two with a series of baffle-plates and separators, the lower baffle-plates being convex and all of the baffle-plates being provided with a series of

riffles extending across the top of the baffle-plates and provided with perforations, as set forth.

631,435. PNEUMATIC HAMMER. Charles K. Pickles, St. Louis, Mo. Assignor to Walter L. Flower, same place.

In a pneumatic hammer, the combination of a piston-cylinder, a handle attached thereto by connecting branches, one of which is formed with a supply-duct, a tubu-



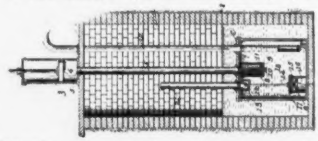
lar eye at the upper end of said branch, a throttle-valve seated in the path of the supply-duct, a semi-rotary handle supported independently of the throttle-valve and having operative connection therewith, a stem on said valve, and a spring holding said valve to its seat, substantially as set forth.

631,701. AIR-COMPRESSOR. Charles F. Du Bois, Denver, Colo. Filed March 10, 1899. Serial No. 708,567. (No model.)

The combination of an inner and outer cylinder, a pair of disks closing the ends of said cylinders and readily-collapsible partitions intermediate the said cylinders and disks and dividing the space between the cylinders and disks into a series of compressible air-chambers; the inner cylinder having sliding air-tight joints with the disks and both cylinders being eccentric in relation to each other during the rotation thereof, whereby the said air-chambers are successively reduced in cubical capacity, as they pass the point of closest approximation of the cylinders; the eccentric displacement of the cylinders being produced by weight applied to one cylinder; and means for collecting the compressed air from the several chambers, all substantially as described.

631,732. COMPRESSED-AIR PUMP. Thos. C. Wristen, Dighton, Kans. Filed Oct. 9, 1898. Serial No. 692,700. (No model.)

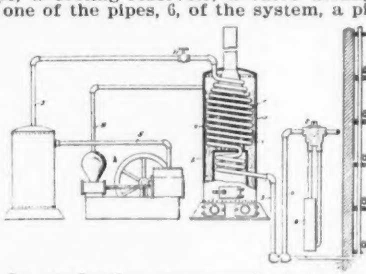
The combination with the reservoir, 18, provided with the inlet-valve, 17, the valve discharge-pipe, 20, communicating with said reservoir, of the air-compression cylinder, 3, the pipe, 6, connecting said cylinder and reservoir, the valve-casing, 11, fixed within said reservoir and encompassing the lower end of said pipe, 6, the valve, 7, spring, 8, and disk, 9, located within said casing, and the set-screw, 10, mounted in said casing and coacting with said disk and spring to close said valve, 7, the casing, 16, the disk, 15, and the float, e, mount-



ed therein, the casing, 13, the valve, 12, mounted therein, the rod, 14, connecting said valve, 12, and disk, 15, and the air-pipe, 22, extending from a point above the water-level, terminating in the reservoir, and in the path of the valve, 12, substantially as shown and described.

631,868. APPARATUS FOR COMPRESSING, STERILIZING AND PURIFYING AIR. Allen Fowler and Andrew J. Harpole, Union City, Tenn.

In an apparatus for the purpose specified, the combination of an air-compressor, a supply duct or pipe adapted to receive air compressed in said compressor, means for heating the compressed air, a distributing-pipe, a cooling-reservoir, a valve arranged in one of the pipes, 6, of the system, a pipe,



17, for conducting compressed air from said pipe, 6, at one side of the valve to the cooling-reservoir, and an outlet-pipe, 12, leading from said reservoir to the pipe, 6, on the opposite side of the valve from the pipe, 17, the valve having formed therein a passage, 14, adapted to connect the two sections of the pipe, 6, and having also grooves or ways, 15, 16, adapted, when the passage, 14, is out of alignment with the pipe, 6, to connect said pipe, 6, with the pipes, 17, 18, respectively, substantially as set forth.

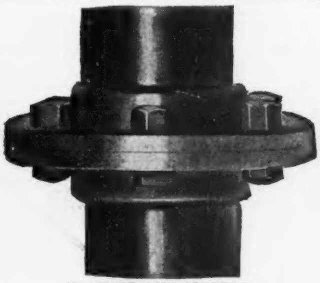
631, 994. AIR-COMPRESSOR. Patrick H. Montague, St. Louis, Mo. Assignor of one-half to Leverett Bell, same place.

An air-compressor, in combination with a cylinder provided with heads at each end, and a partition-wall, of a shaft on which said cylinder is mounted, means for rotating said shaft, a valve for admitting air from the lower compartment into the upper compartment, a valve for admitting air from the exterior into the lower compartmnet, and angled down-spouts, I, arranged on the lower head and near the periphery thereof, substantially as described.

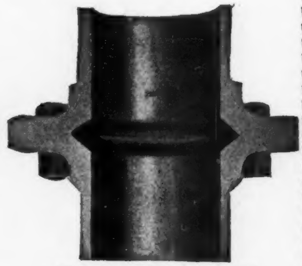
SEAMLESS STEEL TUBING FOR HIGH PRESSURE COMPRESSED AIR.

TUBES UPSET AND FLANGED FOR COUPLING.

UPSET SECTIONAL VIEW.



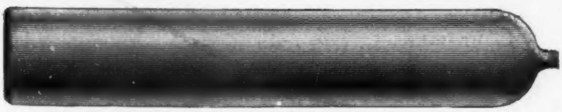
FLANGED AND COUPLED.



FLANGED SECTIONAL VIEW

Seamless Steel Cylinders and Bottles

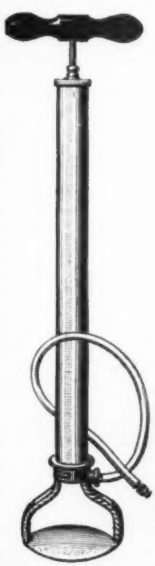
For Storage of Gases and Compressed Air.

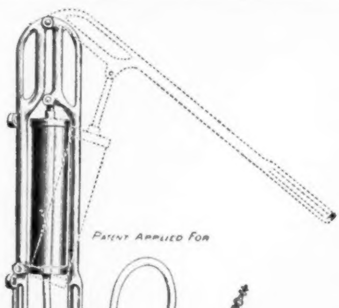


SHELBY STEEL TUBE COMPANY,

General Office, Cleveland, O.
New York Office, 144 Chambers Street.
Chicago Office, 135 Lake Street.
Birmingham Office, 29 Constitution Hill, England.

CORRESPONDENCE SOLICITED.
SUBMIT SPECIFICATIONS





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